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JACK PINE AND ASPEN FOREST FLOORS IN NORTHEASTERN MINNESOTA

Robert M. Loomis, *Fire Control Scientist*
East Lansing, Michigan

ABSTRACT.--Chacteristics of upland forest floors under mature jack pine and aspen in northeastern Minnesota were investigated. These fuel measurements were needed as input for fire behavior prediction models--useful for fire management decisions. The forest floor weight averaged 33,955 kg/ha and depth averaged 7.1 cm. Bulk density averaged 17 kg/m^3 for the L (litter) layer, 45.7 kg/m^3 for the F (fermentation) layer, and 61.6 kg/m^3 for the H (humus) layer. The L layer was found to consist of 65 percent foliage, 31 percent wood and bark, 2 percent herbaceous vegetation, and 2 percent miscellaneous. No significant differences were found in weight, depth, or bulk density, except for the bulk density of the H layer, between the forest floors of jack pine and aspen.

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Rothermel (1972) developed a fire behavior prediction model that is used for fire management decisions. To apply this model to the mature and overmature jack pine and aspen stands in the Boundary Waters Canoe Area (BWCA) of the Superior National Forest, it was necessary to determine the characteristics of the forest floor. Reported here are the weight, depth, and bulk density of the forest floor under these stands.

THE STUDY

Fifteen 0.2 hectare plots in mature jack pine and aspen stands were selected on the Kawishiwi Ranger District of the Superior National Forest in Lake County, Minnesota. These plots were representative of much of the area in the BWCA and showed no evidence of fire within the past 30 years. The stands were on gently rolling topography with shallow sandy loam soils and an occasional exposure of bedrock. Both the jack pine and the aspen stands were similar in age, basal area, and number of trees per hectare (Table 1). Field collections were made from late June through July 1976.

For each plot, 64 uniformly distributed, 12.7 cm diameter circular subsamples were selected to determine the estimated mean weight per hectare of forest floor materials. The estimated weights were determined from initial plots to be within 12 percent of the mean for the L layer, 13 percent of the mean for the F layer, and 17 percent of the mean for the H layer, all with 95 percent confidence limits. Similar material from all subsamples in a plot was then pooled for processing. All sample material was ovendried at 105 C. In addition, the H layer material was ashed in a muffle furnace at 590 C. The reported H layer weight is the loss by incineration. This procedure eliminated both mineral soil and ash from H layer weight. Cones, wood,

Table 1.--*Mean stand characteristics for mature jack pine and aspen forest cover types in northeastern Minnesota.*

Cover type[1]	Plots	Age		Basal area[2]		Trees ≥ 2.5 cm d.b.h.[3]	
		Years	Range	m^2/ha	Range	no/ha	Range
	No.						
Jack pine	9	83	70-105	18	14-24	680	282-1,406
Aspen	6	81	55-90	18	15-20	811	687-1,087
Combined: jack pine & aspen	15	82	55-105	18	14-24	731	282-1,406

[1]Cover types as described by Society of American Foresters (1954).
[2]Multiply m^2/ha by 4.356 to convert to ft^2/acre.
[3]Multiply no/ha by 0.405 to convert to no/acre.

and roots larger than 0.6 cm in diameter or thickness were excluded from the samples. Depth measurements were made at each of the 64 subsample points using the profile exposed by removing the forest floor material. Distinct separation of the forest floor layers was often difficult because there was a gradual rather than an abrupt transition. The most troublesome separation was between humus and mineral soil because a duff mull profile, that includes an A_1 horizon, was present occasionally. The top of the L layer was defined as the highest forest floor particle within 2.5 cm of the point where the profile was measured.

RESULTS

Total weight of forest floor in these stands averaged 33,955 kg/ha of which 2,937 kg/ha was litter (L) layer, 6,860 kg/ha was the fermentation (F) layer, and 24,158 kg/ha was the humus (H) layer. Forest floor total depth averaged 7.1 cm of which about one-fourth was litter. Bulk density averaged 17.0, 45.7, 61.6 kg/m^3 for the L, F, and H layers; respectively (Table 2).

By weight, the L layer contained 65 percent foliage (leaves and/or needles), 31 percent wood (twigs, bark), 2 percent herbaceous vegetation and 2 percent miscellaneous (small cones, flower parts, etc.).

Except for H layer bulk density, there were no significant differences (0.05 level) between the jack pine and aspen stands for weight, depth, or bulk density for any forest floor layer. Thus, all plots were combined. An average of 55 percent of H layer ovendry weight was subtracted as ash and soil.

Table 2.--*Forest floor weight, depth, and bulk density for mature jack pine and aspen forest cover types on shallow upland soils of northeastern Minnesota.*

Cover type[1]	Forest floor layer	Weight[2]		Depth[3]		Bulk density[4]	
		kg/ha	Standard error	cm	Standard error	kg/m^3	Standard error
Jack pine	L	3,031	278	1.7	0.06	18.2	1.67
	F	7,080	422	1.5	.09	48.2	1.85
	H	25,290	3,688	3.7	.38	66.6	3.14
	L+F+H	35,401	4,194	6.9	.50		
Aspen	L	2,794	238	1.8	.08	15.1	1.03
	F	6,532	572	1.6	.09	42.0	2.27
	H	22,460	3,762	4.1	.56	54.1	2.40
	L+F+H	31,786	4,510	7.5	.71		
Combined: Jack pine & aspen	L	2,937	189	1.7	.05	17.0	1.13
	F	6,860	336	1.5	.06	45.7	1.61
	H	24,158	2,612	3.9	.31	61.6	2.62
	L+F+H	33,955	3,026	7.1	.41		

[1]Cover types as described by Society of American Foresters (1954).
[2]All weights are ovendry; H layer weight is weight loss due to incineration; multiply kg/ha by 0.892 to convert to lb/acre.
[3]L layer depth measured from tip of highest leaf, needle, or twig; multiply cm by 0.393 to convert to in.
[4]Multiply kg/m^3 by 100 to convert to kg/ha/cm; multiply kg/m^3 by 0.062 to convert to lb/ft^3.

DISCUSSION

Normally a moisture gradient exists in the forest floor with moisture increasing with depth. This, together with increased bulk density, decreasing volatile content, and increasing ash and mineral content with depth, helps explain why forest floors resist complete consumption from fires. Even a high-intensity fire rarely consumes more than the L and F layers.

These weight estimates are for summer conditions. The L layer is the more responsive to seasonal changes; maximum amount is present after autumn leaf fall (Blow 1955, Loomis 1975) and minimum amount is present just before autumn leaf fall. The difference between maximum and minimum L layer forest floor weight would be approximately equal to annual litter production. Grigal and McColl (1975) reported total litter fall of 1,139 kg/ha/yr under northeastern Minnesota upland mature stands similar to those we studied but with a basal area of only 12.8 m^2/ha compared to the basal area of 18 m^2/ha of our plots. A general relation between annual litter production and latitude as presented by Bray and Gorham (1964) suggests that about 3,360 kg/ha/yr is produced. Litterfall was not measured in this study.

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